ABSTRACT SUBMISSION

To be submitted before Feb. 22nd, 2019 online at https://biomatsante.sciencesconf.org

Biomat – Materials for Health Congress – June 3-7 2019 – La Grande Motte, France

Optimized titanium implant surfaces through femtosecond laser integration in additive manufacturing: enhanced osteogenic differentiation of human mesenchymal stem cells

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Type of contribution desired: ☐ **ORAL** x **POSTER**

☐ Candidating to best presentation award for PhD students/young scientists* ?
(*PhD defense in 2018 or before the end of 2019".

Keywords : additive manufacturing, femtosecond laser, titanium, nanotexturation, biofunctional surfaces, osteogenic differentiation

ABSTRACT

Additive manufacturing (AM) is becoming increasingly important in the orthopedic and dental sectors thanks to two major advantages: the possibility of custom manufacturing and the integration of complex structures. However, at smaller scales, surface conditions are not mastered. Numerous non-fused powder particles give rise to roughness values greater than 10µm (Sa), thus limiting the applications in medical sectors since the surface roughness of metal implants plays a major role in the quality and rate of osseointegration. .

In this study, an innovative hybrid machine combining AM and femtosecond laser (FS) was used to obtain Ti6Al4V parts with biofunctional surfaces. During the manufacturing process, the FS laser "neatly" ablated the surface leaving in its path nanostructures resulting from the laser/matter interaction. Thanks to the intervention of the FS laser, the Sa decreased from 11µm to 4µm and the wettability increased (figure 1).

The behavior of human mesenchymal stem cells was evaluated on these new AM+FS surfaces and compared with surfaces from AM as well as polished surfaces. The number of adherent cells at 24hours was equivalent on all surfaces but the spreading of the cells improved on hybrid AM+FS surfaces compared with their AM counterparts. In the longer term (day7 and 14), the fibronectin and collagen synthesis increased on the hybrid surface as opposed to AM. Alkaline phosphatase activity and mineralization, markers of osteogenic differentiation, strongly diminished on the raw AM surfaces, whereas on the AM+FS specimens they displayed a level equivalent to that on the polished surface. These biological results indicate that using an FS laser during the fabrication of a part makes it possible to optimize the surface state thus favoring osteoblastic differentiation. This new hybrid machine could make it possible to obtain implants with functional surfaces directly at the end of AM without resorting to post treatments.

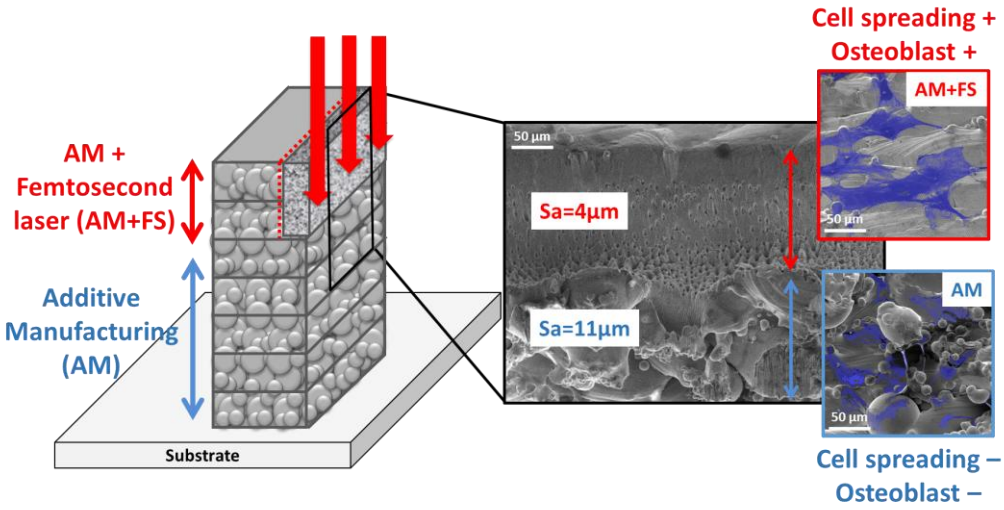

Figure 1: Femtosecond laser action on side surfaces of the sample and scanning electron microscope images showing cell spreading (in violet) on AM and AM+FS surfaces.